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Household biogas development in rural China: On policy support and other macro sustainable conditions

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ABSTRACT

As a fuel, rural biogas is a promising renewable energy source. Policy support is a key initial impetus for industry development. This study explores household biogas development in rural China based on policy support found in literature. Relevant policies, which mainly include directive and guiding policies, economic inspiring policies, research policies, market policies, and other constructive policies, are gradually issued. Moreover, the National People's Congress has enacted five relevant laws, including the Agricultural Law, Renewable Energy Law, Animal Husbandry Law, Energy Conservation Law, and the Act on the Development of Circular Economy. The Energy Law is currently under revision. Relational rules and regulations have also been formed in response to the national policies and laws, which have already produced significant effects. The development of rural household biogas in China is growing steadily, and the technology standard projects have been established. The number of household biogas digesters and biogas annual output in 2010 was double of that in 2005. The offered financial incentive increased from 47 million dollars in 2002 to 760 million dollars in 2011. Policy supports play an important role in rural biogas development. And thus, additional national policy supports are necessary in the fields of scientific research, technological development, and biogas use model.

Contents

1. Introduction

The increasing negative effects of conventional energy sources and the limited stock of renewable energy have forced many

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countries, including China, to look into substitute energy sources [1]. The alternatives should be environment-friendly and renewable to sustain the increase in energy demands [1,2]. The use of renewable energy has become an important component of sustainable global energy strategies [3]. Biogas is a promising fuel, and its construction is an important part of new rural energy and sustainable development in China [4]. Biogas can be produced from a variety of organic raw materials and be used for various energy requirements [5]. Rural biogas construction can promote aquaculture, support production, and improve living conditions in rural areas. With the new countryside construction in China, the state and the farmers see rural household biogas development as an important approach to help solve environmental and rural energy problems [6].

In the 1980s, the central government proposed to set up the biogas industry in rural areas for the rational and effective utilization of agricultural natural resources. The impetus of the biogas industry was related to rural energy development, organic fertilizer development, environmental protection, and health development in rural areas. Therefore, biogas was envisioned to be an important element to achieve agricultural modernization [7]. The annual output of biogas in 2010 was approximately 1.55×10^{10} m^3, which was calculated to be equal to approximately 5.55×10^{11} MJ of heat (the heat of methane combustion is 35.822 MJ/m^3) [8], as shown in Table 1. Therefore, biogas should be regarded as one of the most promising renewable energy [9]. However, approximately only 19% of the potential of biogas has been utilized in rural China [4]. Energy policies play a vital role in mitigating the impact of global warming and in coping with challenge of energy shortage [1]. A biogas policy can promote and stimulate the development of biogas generation. A series of corresponding policies and laws that produced positive effects was issued during the different periods of rural biogas development in China.

China has made significant efforts to pursue energy and resource efficiencies and achieve sustainable development, but it still faces challenges. China should exert more effort in some key areas, especially in rural household biogas construction [10]. The infrastructure of rural China needs to be improved. The energy structure of some rural areas in China mainly focuses on fuel wood burning, which could lead to environmental pollution [11]. Coal price and electrovalence are high in rural and poor areas in China. The development of regional economies between urban and rural areas is uneven, where the popularization of new energies, such as natural gas and coal gas, is obstructive. The construction of rural household biogas, which is considered a livelihood project, could play an important role in countering the challenges above [12]. However, with the new countryside construction and urbanization promotion in China, rural biogas construction cannot keep pace with the social economic construction in rural areas [13]. The current paper presents a comprehensive overview of rural biogas development in China, mainly from the viewpoint of biogas digesters built. This study mainly aims to analyze policy support and law guarantees related to rural household biogas development and their effects.

Table 1
Number of household biogas digesters built and annual output of biogas in China.

Year	The number of biogas digesters (10^4)	Annual output of biogas (10^8 m^3)
1996	602.1	16.3
1997	638.2	17.7
1998	688.8	19.8
1999	763.5	22.5
2000	848.1	25.9
2001	956.8	29.8
2002	1109.9	37.0
2003	1288.9	45.8
2004	1541.0	55.7
2005	1800.0	69.0
2006	2200.0	85.0
2007	2650.0	102.0
2008	3050.0	122.0
2009	3507.0	124.0
2010	4118.0	155.0

2. General situation of household biogas development in rural China

2.1. Household biogas development and its characteristics

Biogas research and utilization in China have long histories, and hydraulic digesters have been used for nearly 100 years [14]. China is one of the pioneering countries in the world that developed anaerobic fermentation [6]. Biogas development in rural China has gone through three main stages since 1949, including types of energy demand, ecological demand, and ecological home development [15]. The nationwide implementation of the Eco-Household Project marked the milestone of the biogas industry in China [16]. Biogas costs approximately US$0.095 per m^3 [17], while the prices of nature gas and liquefied petroleum gas are approximately US$0.383 and US$1.037 per m^3, respectively [18], showing that biogas is much cheaper and easier to distribute in rural and poor areas in China. Rural biogas construction continuously consolidates and improves under policy support and legal protection. The characteristics of rural household biogas development are mainly reflected in the following aspects: (i) state funding continues to increase; (ii) household biogas scale grows steadily; (iii) various types of biogas projects are established; (iv) comprehensive utilization benefits of biogas improve; (v) service system construction is in full swing; (vi) technical standards system is formed; and (vii) the contribution to the energy saving of biogas development is significant. The effects above were obtained under policy encouragement and legal protection, but still with drawbacks. Domestic research on biogas power generation and the application markets are imperfect. Thus, higher technological demand is requested for researchers, and more studies related to scientific research and technological development are necessary.

2.2. Situation and characteristics of the built household biogas digesters

The number of biogas digesters built and the annual output of biogas continuously increase with the steady growth in household biogas scale. The large-scale development of household biogas in rural China began in the 1970s [4,19]. From 1973 to 1983, rural biogas development fluctuated dramatically [4]. The number of household biogas digesters built in the early 1970s was 6×10^6, which increased to more than 7×10^6 in the mid-1970s but fell to less than 4×10^6 in the early 1980s [20]. During this early stage, the challenges in household biogas production included poor management and the lack of secure and mature technologies to support the industry. From 1984 to 1994, the rural biogas construction remained in an adjustment period, with 8.27×10^5 new households using biogas [4]. This period focused on the scientific research of technological systems and repair of pathological digesters, and thus, the development pace slowed down. However, the pace of biogas development steadily increased annually from 1994 to 2000. During this period, biogas development picked up, and approximately 50,000 new biogas

digesters were built annually [21]. In 2006, the number of household biogas digesters in rural China was the highest in the world [22]. Household biogas digesters were gradually distributed throughout China, mainly in the Yangtze River Basin [23]. The number of built household biogas digesters and its annual output in 2010 was more double of that in 2005 [21,24] (see Table 1).

In 1999, the Ministry of Agriculture compiled the country's fruitful experiences and established the "Energy-Environment Project" and the "Eco-Household Project" that served as ecological models for energy projects [16]. Other models related to household biogas digesters were also conceived during this period. The "Three in One" eco-agricultural model combines the biogas digester with a pigpen and toilet [25], the "Four in One" eco-agricultural model added a solar greenhouse [26], and the "Five in One" eco-agricultural orchard model added a water-saving irrigation system [27]. The ecological models promoted the synergy of social, economic, and ecological benefits for the realization of sustainable development in ecological agriculture [28]. However, a breakthrough in the model of biogas use was necessary. To guarantee those farmers who are not fit to build their digesters, can get clean and efficient biogas energy supply, the biogas model should not be limited to a "one household, one biogas digester" policy.

2.3. Obstacles in the development of household biogas

With livestock and poultry breeding fading out from farmers, biogas fermentation material could fall short. Technical development and management were stalled in the rural and poor areas in China. High population growth rate in rural areas caused the lack of skilled labor and technical personnel in the labor market, and the industrialization of poor and backward areas became blocked [29]. Biogas popularization is difficult to realize because of the uneven development of regional economies between urban and rural areas. Microflora plays a key role in biogas generation through anaerobic fermentation, but only few studies on this field have been reported. Moreover, the straw pre-treatment of anaerobic fermentation poses some problems. Thus, policy support for rural household biogas development from the government and all social circles are necessary.

3. Macro sustainable conditions of household biogas construction in rural China

3.1. Policy support

Policy support is a key initial impetus for industry development. Based on predictions, China is one of the regions in the world that will suffer the worst impacts of climate change [30–32]. Thus, biogas development can be one of the countermeasures in China's economic agenda. A series of constructive policies was proposed from the viewpoint of long-term effective development systems of bioenergy industries in China [33]. Biogas development in China is an eco-household project that has been incorporated into the national bond project and has been one of the priority tasks of the Chinese government [34]. Policies on renewable energy development have emerged starting 1995 [34,35] (Table 2).

3.1.1. Analysis of policy support

The national macro policy support is important for the construction of household biogas in rural China. Policies play important roles in many aspects (as shown in Table 2), such as strengthening strategy research (the National Development and Reform Committee [2006]), enhancing scientific research input

Table 2
Policy support for household biogas development in rural China.

Policies	Relevant contents	Remarks
To propose the objectives, tasks, and priorities of the new and renewable energy projects between 1996 and 2010	New and renewable energy projects can be brought into the long-term social and economic development plan to encourage the utilization of renewable energy	In 1995, the State Development Planning Commission, Science Commission and Commission of National Economy and Trade
To make the development outline of new and renewable energy between 1996 and 2010	Include the new and renewable energy projects, and the Biogas Popularization Project was constructed in 2005	In 1996, the former State Development Planning Commission
To promulgate some standards	Include 30 standards concerning renewable energy, 6 industrial standards, and 3 technical standards, which had been implemented in various industries	Since the reform and at the start of 1996, related commissions
To set up test points among counties	The rural areas in the pilot counties should have access to electricity and gas	In December1983, the State Council
To propose the objectives, tasks, and polices	To develop biogas, energy-saving stoves, and other new energy and new energy-saving technologies. To strengthen the comprehensive energy construction in rural areas. To fulfill the transformation of rural power network and achieve the same cost of electricity use between urban and rural areas	In 2000, the State Development Planning Commission and Science Commission
To set up the discount credit of rural energy	The central Financial Department provides the capital to subsidize renewable energy projects in the interest of 50% of the Industrial and Commercial Bank	Economic inspiring Policy: in 1987, the State Council
To give loan preference to renewable energy projects	Notice on supporting the development of renewable energy, they employ economic policy to promote the development of renewable energy	Economic inspiring Policy: in 1999, the State Development Planning Commission and the Science and Technology Ministry.
Create preference polices for renewable energy projects	Preference is mainly in value added tax. The Ministry of Finance and the local governments made them employ the economic policy to promote the development of renewable energy	Economic inspiring Policy: the State Development Planning Commission and the Ministry of Finance
To be exempted from enterprise revenue tax	The new enterprises of renewable energy in the high-tech industry zones can be exempted from enterprise revenue tax for two years	Economic inspiring Policy: the State Development Planning Commission and the Ministry of Finance
Subsidy policy of renewable energy	The related Ministry and the local government subsidize the management, construction, investment, research, and development of renewable energy projects	Economic inspiring Policy

Table 2 (*continued*)

Policies	Relevant contents	Remarks
	sources that can replace oil and the support for the use of renewable energy by building heating and cooling systems	
Temporary measures of aid fund on raw material based on bio-energy and bio-chemical industry	To make bases for bio-energy materials and bio-chemical materials and authorize the corresponding expenditure. Leading enterprise should be responsible for demonstration of biomass energy and biochemical industries	The Financial and Economic Committee and Construction [2007] number 435
Temporary measures of additional income regulation of renewable energy power	The measures referred to renewable energy include biomass power generation and biogas power generation, among others	The National Development and Reform Committee Price [2007] number 44
On accelerating the comprehensive utilization technology of straw	To develop biomass energy through biogas construction and improve the energy structure of countryside gradually based on country environmental regulation	The State-run [2008] number105
Temporary measures of aid fund on utilization of straw for energy	To support the companies who engage in straw briquette, straw gasification, and straw energy regeneration	The Financial and Economic Committee and Construction [2008] number 735
Policy on improving the generating tariff of agriculture, forestry, and biomass powers	Benchmarking grid rate policy on biomass power projects that involve agriculture and forestry, and the related enterprises should agree to be supervised and inspected	The National Development and Reform Committee Price [2010] number 1579
To strengthen the agricultural and rural infrastructure and optimize the energy structure	To develop biogas and other energy-saving technologies and strengthen rural energy development. Actively develop wind, solar, and other new and renewable energy and promote energy saving and comprehensive utilization of technology. Encourage to establish the central government investment projects and construction funds into the central budget	The 10th Five-Year Plan (2001–2005) for National Economic and Social Development
Key projects on ecology protection and the new countryside construction	Strengthen the governance of rocky areas through the construction of rural biogas and other measures. Actively develop rural biogas, straw regeneration, and other renewable energy sources and improve the rural power grid	The 11th Five-Year Plan (2006–2010) for National Economic and Social Development Column 12; 18
To strengthen the rural infrastructures	Strengthen rural energy development, and implement new round upgrade of rural power grid construction. To develop utilization of biogas, crop residues, forestry wastes, and other	The 12th Five-Year Plan (2011–2015) for National Economic and Social Development
To propose the major points of the technology policy	To provide guidance by technical policy, suit the interests of the enterprises, and conform to the rules of market economy development in twelve fields	Research Policy: in May 1986, the State Council
To set the task funds of renewable energy	With investments of US$1.58 $\times$ 10^8 annually to research for renewable energy projects by supporting the construction and demonstration of projects	Research Policy: Since 1978, the Science and Technology Ministry
To build training network	Train talents, spread techniques, and promote the development of renewable energy and rural energy. By 1997, the 378,000 trainees were accounted for	Research Policy: the Agricultural Ministry
To build promotion systems and team to spread rural energy techniques	Make use of the promotion system, strengthen the implementation, and build the technological team since the State reform and opening up	Market Policy: the Agricultural Ministry
Interim Provisions on project management of the capital and construction of new energy	The economies of scale: biogas digesters with gas production of 5000 m^3 or above can be provided with US$4.74 $\times$ 10^6 or more	The State Development Planning Commission [1997] number 955
The Catalog of development of the renewable energy industry	To combine biogas development with gas supply and power generation, including large-scale livestock and poultry farms and breeding areas, among others	The National Development and Reform Committee [2005] number 2517
Management regulations for electricity generation from renewable energy	For biogas generation directly switching-in the distribution network and the access system, in principle, should be invested and constructed by the power grid enterprises	The National Development and Reform Committee [2006] number 13
Trial management schemes for renewable energy prices and cost-sharing	Scope: biomass power generation, such as biogas power generation	The National Development and Reform Committee Price [2006] number7
Interim measures on special fund management for development of renewable energy	The measures specify that renewable energy development and utilization projects, including rural biogas, could apply for support from existing capital resources	The Financial and Economic Committee and Construction [2006] number 237
Proposals for Implementation of Tax Support Policy on development of bio-energy and bio-chemical industry	Ministry of Finance should work with experts of the relevant departments to make special evaluation of local biomass energy and establish policy support mechanisms	The Financial and Economic Committee and Construction [2006] number 702
Guidelines for using public fund for renewable energy development	One support for renewable electricity generation, including wind, solar, and ocean. The other two priorities are research on energy	The National Development and Reform Committee [2006]

Table 2 (*continued*)

Policies	Relevant contents	Remarks
	renewable energy. To strengthen the reform of coal and wood savings	
Management method on national debt projects of rural biogas construction	The project has made the basic unit set up the standards and objects of subsidy of the central investment and formulate principles of rural biogas construction	The Financial and Economic Committee and Construction

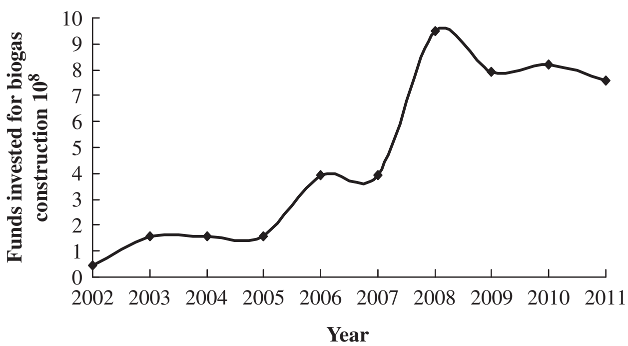


Fig. 1. Economic support for rural biogas construction over the last 10 years in China.

(the Financial and Economic Committee and Construction [2006]), persisting technology innovation (the Agricultural Ministry), establishing product quality standards, improving industrial standard systems, opening markets, and accelerating commercialization. The 10th and 12th Five-Year Plans for National Economic and Social Development proposed to optimize energy structure and strengthen the rural infrastructure, which have progressed to some extent. The 11th Five-Year Plan for National Economic and Social Development Column 12 and 18, has proposed to form the key project on ecology protection and the new countryside construction, wherein posed to actively develop rural biogas, straw regeneration and improve the rural power grid. The number of rural household biogas digesters in China increased by 1.29-fold at the end of the 11th Five-Year Plans.

The main effects of policy support in rural biogas development are reflected in the following aspects. First, state funding continues to increase (see Fig. 1). Second, the growth in household biogas scale is steady. The number of national household biogas digesters increased from less than 1 million in 2001 to 3.5 million in 2009, with annual biogas output of 12.4 billion m^3 and average growth of 29.1%. The national utilization rate of household biogas is approximately 85%, and biogas technology has become popular in rural areas, where test points were set up. Fermentation with mixed feedstock can achieve significant progress toward biogas development. Third, various types of biogas projects are rapidly developed. Large-sized, medium-sized, and small-sized biogas projects had increased by 30.0%, 46.5%, and 42.2%, respectively, from 2003 to 2009. Energy projects, such as the Eco-Household Project, National Debt Project, and the Biogas Popularization Project, have been in progress since 2005 in provinces and municipalities. The construction of energy projects is an important measure of improvement in the economic conditions of residents in the rural areas and in the ecological environment of Midwest China [36]. Fourth, service system construction is in full swing, wherein a "National Rural Biogas Service System-Building Program (Trial)" was issued in April 2007. Fifth, a technical standard system is formed. Thirty-one biogas standard projects were formed in 2009, 21 of which involve household biogas digesters. Finally, biogas development is significant for energy conservation and pollution reduction. Biogas utilization in 2009 reached approximately 13.3 billion m^3, and thus, biogas can serve as substitute for fossil energy amounting to 21 million tons of standard coal and it can reduce CO_2 emissions by approximately 51 million tons [20]. Long-term benefits from biogas development and utilization can be obtained with support from international Clean Development Mechanism project.

With the new countryside construction in China, rural biogas construction cannot keep pace with the social economic construction in rural areas [13]. Policies that affect the uneven development of regional economies between urban and rural areas should be issued to promote biogas popularization. Moreover, additional policy support is needed for the future development of rural household biogas.

3.2. Laws and regulations

Policies are mainly implemented by legal means, while laws and regulations are created under certain policies. The National People's Congress have enacted five main corresponding laws and regulations, including the Agricultural Law, Renewable Energy Law, Animal Husbandry Law, Energy Conservation Law, and the Act on the Development of Circular Economy. The Energy Law is currently under revision [37] (see Table 3).

3.2.1. Effect analysis of laws and regulations

Biogas has been exploited and utilized rationally according to state encouragement and legal guarantees. The construction of rural household biogas is expected to strengthen, as indicated on the lists of "China's Agenda of the 21st Century," "Long-term Planning of National Economic and Social Development," and "Long-term Planning of Renewable Energy Sources." The "National Rural Biogas Development Plan between 2006 and 2010," which was laid down by the Ministry of Agriculture [38], proposes that 40 million households will use biogas by 2010, and the goal has realized. The number of household biogas digesters and biogas annual output in 2010 was more double of that in 2005, reached 41.18 million and 1.55×10^{10} m^3, respectively.

The Act on the Development of Circular Economy has been enacted in six legal systems, one of which aims to enhance effective stimulating measures. In 2008, the funds invested for rural biogas construction reached US9.49×10^8, and the number of rural household digesters reached 3.05×10^7. The technological growth of biogas development is promoted under the Energy Conservation Law, which is being used in small-sized household biogas and in organic wastewater, and domestic sewage treatments. The energy structure in rural China would be improved with developing bioenergy with the Energy Law to be enacted. Relevant laws as well as policies can guarantee the smooth development of rural household biogas. However, new laws pertaining to the development of rural biogas, such as laws related to biogas power generation and application markets, need to be established.

3.3. Established rules and regulations

To ensure the popularity and consolidation of biogas industry, a series of rules and regulations has been established in response to policies and laws [39]. China needs policies and an adequate program to build environments that encourage rural household biogas construction [40]. One of the program goals ending 2005 is

Table 3
Law assurance for rural biogas construction in China.

Laws and regulations	Corresponding contents	Remarks
Agricultural Law in 2002	Article 57. To develop agriculture and rural economy renewable and clean energies, including hydropower and biogas must rationally be exploited and utilized	The National People's Congress
Renewable Energy Law in 2005	Development of renewable energy is a national responsibility and civil obligation	The National People's Congress
Animal Husbandry Law in 2005	Article 39. Include biogas digesters and other safe disposal facilities for the comprehensive utilization of manure, wastewater, and other solid wastes	The National People's Congress
Energy Conservation Law in 2007	The State encourages and supports the development and utilization of new and renewable energy	The National People's Congress
Act on the Development of Circular Economy in 2008	Article 34. The State encourages and supports straw, manure, and agro-industrial by-products to make a comprehensive utilization. To develop and utilize biogas and other biomass sources	The National People's Congress
Energy Law	Article 5. To optimize the energy structure actively and encourage the development of new and renewable energy	Revising

bioenergy, wherein gas supplies from highly efficient bioenergy, including large- and mid-scale biogas generated from industrial organic waste water, farm waste, and biomass gasification systems, should be increased to almost 2 billion m^3 [35]. And the goal has achieved, as of 2005, more than 4000 units of bioenergy facilities produce 8 billion m^3 of biogas annually. Bioenergy utilization has reached more than 20 million households in the rural areas, with biogas as the main biofuel [41]. The main rules and regulation for household biogas construction in rural China are as follows:

(1) Operational systems improved. For example, rural energy offices were set up in 30 provinces in China, and in more than 1900 counties. The staff of the energy offices are responsible for the administration and organization of the development plans of rural biogas, improvement of the comprehensive utilization of rural energy, demonstration and promotion of pilot technology [17], hosting and organization of the implementation of Eco-Household Project and other projects related to the biogas industry, and guidance of the industrial development of rural energy and service system.
(2) Trade Management is building to lay down the following areas: quality supervision for rural energy products, equipment, and technical standards, guidance of biogas construction, organization of technical training of the rural energy industry, implementation of the examination and assessment of the work of employees in this vocation, and administration of funds supply.
(3) System building, which includes "Management measure for pollution control of livestock farms" and "Emission standards for pollutants of livestock breeding industry," was built in May 2001. The number of rural energy standard programs in 2010 created by the Ministry of Agriculture reached 11,690, and 33 of which are concerned with rural household biogas.
(4) Other aspects related to the rules and regulations of rural household biogas are as follows:

- Rural household biogas: 23 standards concerning rural household biogas, which consisted of 6 national standards and 17 agricultural industry standards, have been initiated. The standards involve the operating procedures of biogas fermentation, biogas generator sets, collection of biogas digesters, and technical code for work.
- Large and medium biogas projects: 10 standards concerning biogas projects, all of which are agriculture industry standards, including engineering classification, engineering design and construction, inspection, safety operation, and biogas power generation were initiated.
- National Standardization Technical Committee of Biogas (TC515); Secretariat of ISO Working Group on Biogas (TC255).

3.4. Financial incentives

Economy-inspiring policies can be effective measures for the development of renewable resources [42]. The state strengthened support for biogas development by providing bond funds, in which only the central investment in biogas construction has reached more than US$3.8 billion from 2003 to 2010 (Fig. 1). During the 10th Five-Year Plan, China arranged for more than US$$1.6 \times 10^8$ to support the research and development of advanced technologies involving biogas, particularly by the Key Technologies R&D Program, the 863 Program, the 973 Program, and the Industrialization Program. The Chinese government invested bond funds of US$$1.58 \times 10^8$ annually from 2003 to 2005, which reached as high as US$$3.95 \times 10^8$ in 2006 [15]. Government departments have received increased funding to accelerate the development of rural biogas, improve the ecological environment, and promote economic and social prosperity [43]. The standards, as well as the total amount of financial subsidies for biogas, are increasing in number [44]. Among the new investment agricultural projects that stimulate domestic demand established by the Center in 2008 and 2009, funds for biogas projects reached more than US$1.58 billion, and funds meant to promote local and enterprise self-financing totaled nearly US$4.74 billion [45]. The financial subsidy increased from 47 million dollars in 2002 to 760 million dollars in 2011. These levels of funding made the scale of rural biogas construction and its technical level assume a leading position in the world [38].

4. Discussion and prospects

Based on the description and analysis above, rural household biogas development has evidently improved. Biogas development has been the main starting point of new rural construction and it has become an important component of sustainable energy strategies. China continues to face challenges in transition to a low-carbon economy, but the construction of rural household biogas, which enjoys national policy supports, could play an important role in countering such challenges. Rural biogas infrastructure in China has been improved. The coverage of household biogas service network of households with digesters in rural China in 2009 reached approximately 40 percentages. In addition, financial subsidy is increasing substantially.

Rural household biogas development in China is in a good state. However, domestic research on biogas power generation and application markets remain imperfect and the straw pretreatment of anaerobic fermentation continues to experience problems. Spent liquor can cause pollution, and the popularity of the pretreatment technology is difficult in rural areas. Thus, future development of rural biogas may focus on the following characteristics:

(1) More tertiary institutions, research institutions, social organizations, and production companies will join the rural biogas technology research and promotion, the biogas technology will mature, and market competitiveness will increase. More companies will start to process biogas auxiliary products, and multi-purpose use efficiency of rural biogas will improve.
(2) Biogas construction is one of the important industries in stimulating domestic demand because of the great demand for building materials and related products. The production and consumption of cement, steel, gravel, and brick building materials will continue.
(3) Biogas projects will provide many jobs for surplus rural labor and migrant workers returning home, alleviating employment problems and increase the income of farmers.
(4) The opportunity for biogas development will be even brighter than before. Moreover, the system of a national policy framework will be clearer and more systematic in the future.
(5) Studies on stalk pretreatments and microbe role in the fermentation process will increase. Microflora plays a role in biogas generation by anaerobic digestion. The relationships among microbial populations during fermentation should be explored, and corresponding control methods should be established.

5. Conclusion

This paper discussed household biogas development and its characteristics in China under the guarantees of various policies and laws. Moreover, the outstanding achievements in this field, such as the number of new biogas digesters built and growth output of biogas, were presented. Five relevant laws and many national macro policies for rural household biogas have been established and issued gradually, and they have produced significant effects. A good policy on biogas development can facilitate the system of biogas construction. The number of household biogas digesters in 2010 was double of that in 2005, and annual biogas output increased by 1.25-fold. In addition, financial subsidy continues to increase substantially.

Household biogas development in rural China is in a good state, but certain drawbacks remain, and thus, domestic research on biogas power generation and application markets is necessary. And more studies on fermentation technology, such as stalk pretreatment and microbe role in the fermentation process, are needed. With the development of rural household biogas, additional related policies and laws should be generated and issued in the fields of scientific researches, technological improvement, rural biogas infrastructure, and biogas use models.

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